Geomorphological studies of the Sedimentary Cuddapah Basin, Andhra Pradesh, South India

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Abstract: *The crescent shaped Cuddapah basin located mainly in the southern part of Andhra Pradesh and a little in the Telangana State is one of the Purana basins. Extensive work was carried out on the stratigraphy of the basin, but there is very little reference (Vaidynathan,1964) on the geomorphology of the basin. Hence, an attempt is made to present the geomorphology of the unique basin. The Major Geomorphic units correspond to geological units. The important Physiographic units of the Cuddapah basin are Palakonda hill range, Seshachalam hill range, Gandikota hill range, Velikonda hill range, Nagari hills, Pullampet valley and Kundair valley. In the Cuddapah Basin there are two major river systems namely, the Penna river system and the Krishna river system. The Penna river system has more network of rivers than the river system of Krishna. Further, the Pennar river system drains the southern half of the basin, whereas the river Krishna drains mainly the northern most part of the basin. There is no major river in between these two. The rivers of Pennar systems have their origin from Mysore upland area, whereas the rivers of Krishna systems have their origin from the northern Karnataka area. Most of the rivers are superposed. They are mainly controlled by the structural features / elements.*

The basic drainage patterns noticed are sub-parallel, sub-dendritic, radial, trellis and angular. In addition to these, internal drainage is very conspicuous in carbonate terrain and are controlled by the lithology and structure. The landforms can be divided into structural landforms, fluvial landforms and denudational landforms. Structural landforms: Cuesta, hogback, structural ridge, structural plateaus, mesa, domes. Fluvial land forms: Water channel with flood plain, alluvial fans, piedmont zone, valley fill and solution forms. There is well developed karst topography in the basin in the limestone of the Kurnool Group. In addition to all these, the famous Natural Arch is also an eye catching geomorphic feature of the basin. The critical study of cross sections along certain latitudes and along the hill ranges revealed a number of erosional surfaces in and around Cuddapah basin. These surfaces are correlated with the surfaces noticed in the Karnataka and Tamil Nadu. They are, i. Annamalai Surface - at an altitude of over 8000' (2424 m), ii. Ootacamund Surface – at 6500'-7500' (1969-2272 m) on the west and at 3500' (1060m) on the east as noticed in Tirumala hills, iii. Karnataka Surface - 2700'-3000' (Vaidynathan, 1964). 2700-3300 (Subramanian, 1973) 2400-3000 (Radhakrishna, 1976), iv. Hyderabad Surface – at 1600' – 2000'v. Coastal Surface – well developed east of the basin.vi. Fossil surface: The unconformity between the sediments of the Cuddapah basin and the granitic basement is similar to 'Fossil Surface'.

Key words: *Topography, Land forms, Denudational, Pediment zone, Fluvial.*

INTRODUCTION

Cuddapah basin is a treasure house many economic minerals like barytes, cement grade limestone, dolomite, steatite, asbestos and fullerin. Abiogenic gas has also been reported in the Putluru Mandal of Anantapur District. It is possible to occur similar gas incidence in Owk Mandal of Kurnool District. This reflects that Cuddapah basin has immense mineral wealth.

Groundwater is very essential to one and all especially to farmers. The potential of groundwater can be ascertained by studying applied geomorphological aspects of the basin. In other words, the hydro geomorphological conditions of different landforms will help in assessing the potential of groundwater. Lithology controls the evaluation of landforms. It means there is a direct link between geology and geomorphology. Geology of the Cuddapah basin was very well documented by many.

The first account on the Cuddapah basin was given by King (1872). Vaidynathan (1964) described the geomorphology of the basin. Nagaraja Rao et al (1987) presented a detail account on the Cuddapah basin, especially on stratigraphy, geology, structure and tectonics and evolution etc. The Cuddapah basin geomorphology will be an ideal study for all the students of geomorphology because all aspects of geomorphology like landforms study, control of lithology on the evolution of landforms, planation surfaces and utility of geomorphology in groundwater exploration etc, can be studied in detail. Hence, detail study of geomorphology was taken up by the authors.

PHYSIOGRAPHY OF THE BASIN

The Major Geomorphic units correspond to geological units (Vaidynathan, 1964). The important Physiographic Units of the Cuddapah Basin are, Palakonda hill range: As per the SOI topographical maps, the south western hill ranges where the abode of lord Venkateswara is located is called Palakonda hill range. Seshachalam hill range: The hill range located SW of Pulivendula is designated as Seshachalam hill range as per the topographical maps of SOI. In fact, the names should have been the other way. The present Seshachalam range should have been designated as Palakonda hill range because the temple of Lord Siva called Palakonda Rayudu locally is located in this hill range. Similarly, the present Palakonda hill range as shown in the map should have been Seshachalam hill range named after one of the seven hills of Lord Venkateswara. As these are given by SOI, it may not desirable to interchange at this stage (Figure 1). Gandikota hill range is named after the Gandikota port of Vijayanagara dynasty. Velikonda hill range as the name indicates is the outer most hill range of the basin.Nagari hills and Pullampeta valleys are named after the geographical locations.

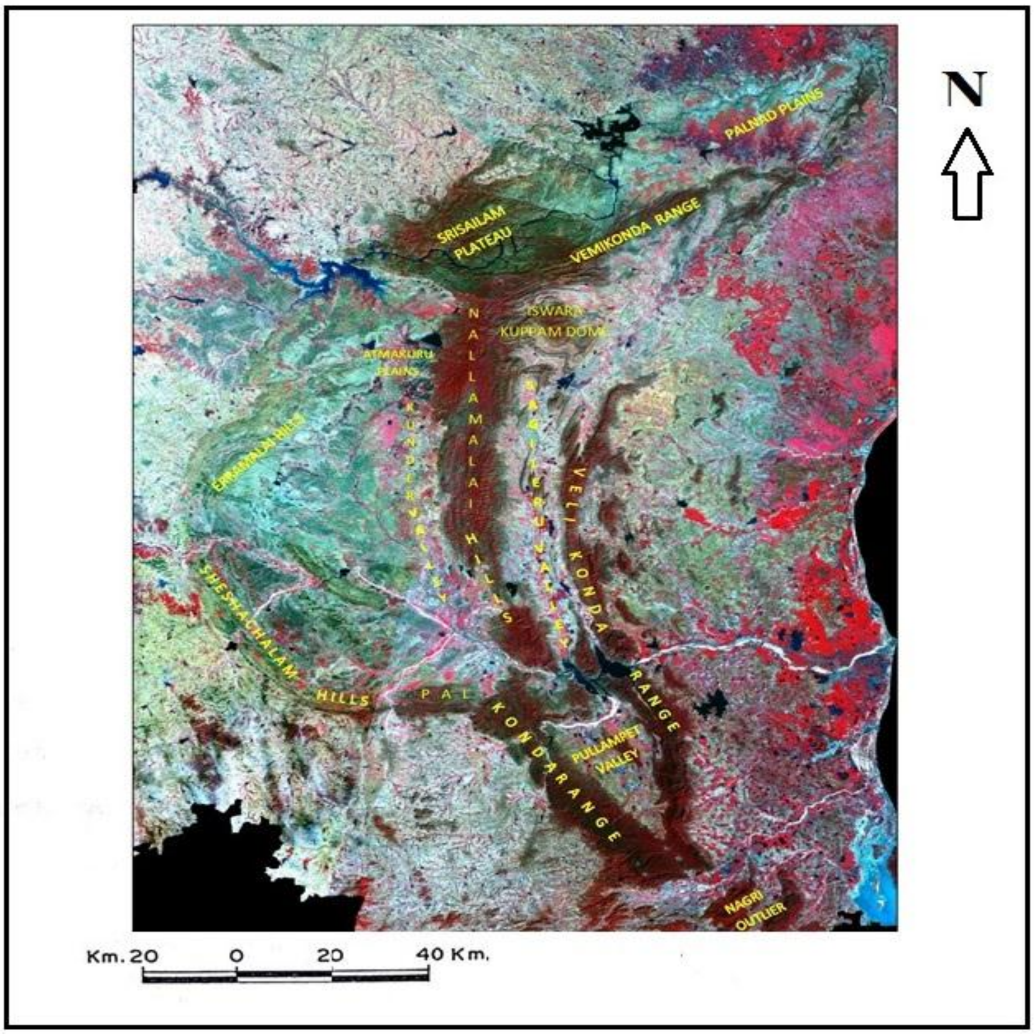

Fig 1: Physiographic Features of Cuddapah Basin

RIVER SYSTEMS AND DRAINAGE PATTERNS

In The Cuddapah Basin there are two major river systems. The Penna river system and the other Krishna river system. The Penna river system has more networks of rivers than the river system of river Krishna. Further, the Penna river system drains the southern half of the basin, whereas the river Krishna drains mainly the northern most part of the basin. There is no major river in between these two. The rivers of Penna systems have their origin from Mysore upland area, whereas the rivers of Krishna systems have their origin from the northern Karnataka area. The rivers namely Cheyyeru, Papaghni, Chitravati, Kundair and Sagileru are the major tributaries to the river Penna. The drainage of Cuddapah basin and its surrounding areas clearly reflect the role played by lithology and structures in the development of various patterns. The major river development is due to the superposition of them on about 3000' above MSL and gradual lowering of rivers since mid-tertiary times (Vaidynathan, 1964).

Various drainage patterns have been identified in the basin, which are basically controlled by the lithology and structure. Most of the rivers in the basin are superposed. Consequent, subsequent, obsequent streams are all guided by topographic slope. The basic patterns noticed are sub-parallel, sub-dendritic, radial, trellis and angular. In addition to these, internal drainage is very conspicuous in carbonate terrain. The drainage patterns are mainly controlled by lithology and structure (Figure 2).

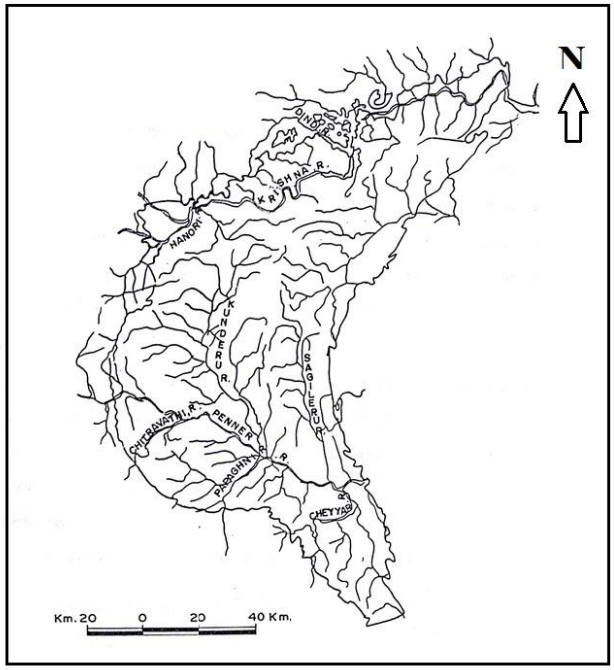

Fig 2: River System and Drainage Pattern in the Cuddapah Basin.

MAJOR LANDFORMS

The landforms can be divided into structural landforms, fluvial landforms and denudational landforms and karst topography (Figure 3). Structural landforms: - The western part of the Cuddapah basin shows homoclinal nature, resulting in the development of cuesta type of topography. All along the western margin the Quartzite of Gulcheru and Nagari stand up like a wall representing the obsequent slope and dip into the basin at shallow angle reflecting the consequent slope. This type structural landforms continues up to the centre of the Papaghni sub basin, where the majestic Gandikota Quartzite stands out with a typical cuesta set up. The carbonates of Vempalle Formation, the Pulivendula Quartzite and shale beds of Tadipatri Formation, all exhibit cuesta type of landform. However, the carbonates of Vempalle formation, because of their lithological nature reflects denudational landforms.

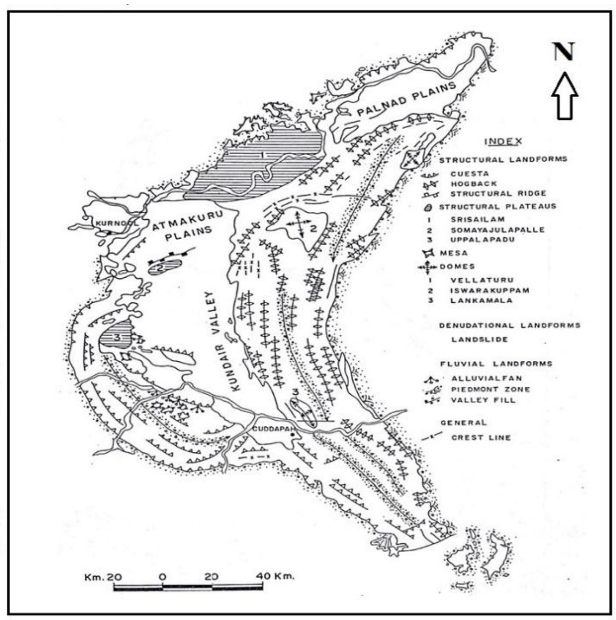

Fig 3: Geomorphological map of Cuddapah Basin in showing Different Landforms

The Nallamalai sub basin located on the eastern side of the Cuddapah basin has number of structural landforms. In fact, Nallamalai sub basin is called Nallamalai fold belt. In this sub basin the spectacular structural landform is Iswarakuppam dome. It exhibits alternating sequence of quartzite and shale/ phyllite. The core of the quartzite unit of the dome shows qua-qua versal dip. It is opined that dome has developed due to the granitic intrusion into the sediments. But in this area the granite has not cropped out, because of huge thickness of the quartzite of the dome. However, in the Ipuru and Nekarikallu domes that are located in the NE parts of the basin, where the intrusive granites are seen in the core of the dome. There are minor domes like Lankamalai dome within the Nallamalai sub-basin. Almost all the quartzite units in the Nallamalai fold belt can be considered as structural landforms representing either doubly plunging anticline as in the case of Mokshagundam ridges, Hogbacks and Cuesta has seen in the Velikonda hill range.

The first order topography reflecting the anticlinal hills and synclinal hills is conspicuous north of Cheyyeru River in the Nandaluru area. The anticlinal hills are constituted by the Bairenkonda Quartzite and the synclinal valleys have the Cumbum formation (softer rocks). South of the Cheyyeru River in the Pullampet formation (Homo-taxial with the Cumbum Formation), the hills having carbonate and quartzite represent synclinal structure and the valleys having mainly carbonate indicating anticlinal structure i.e. the second order topography. In this case, the development of second order topography is mainly due to deposition and erosion.

Nagari outliers are the majestic hills of the Nagari Quartzite (equivalent to Bairenkonda Quartzite) reflect the second order topography i.e. these quartzites are mainly doubly plunging synclinal hills. Some of them are refolded folds. This topography is mainly due to deposition of Nagari Quartzite in the basin located on the granitic basement. The Srisailam Quartzite located in the northern part of the basin exhibits plateau type of landform due to its sub-horizontal nature. This can be considered as structural plateau. The rocks of Kurnool Group are all sub-horizontal and exhibit mesa type of landform (Figure 4).

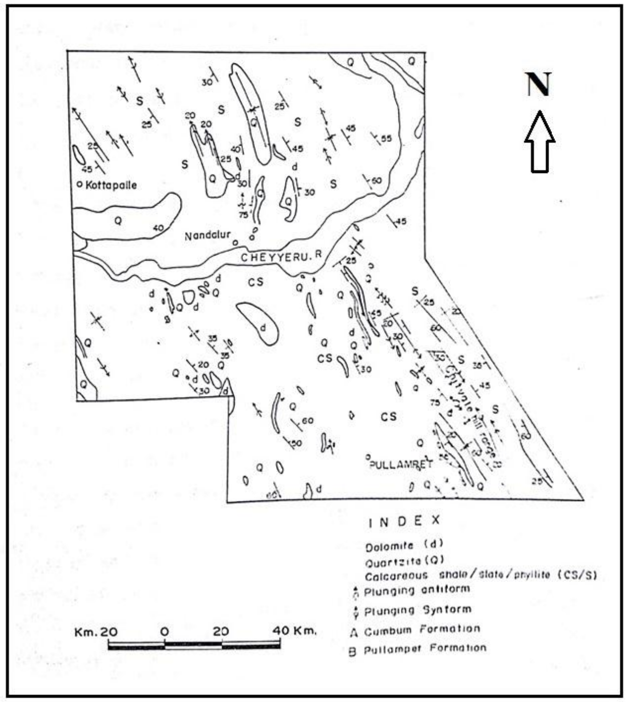

Fig 4: First and Second Order Topography in the Cumbum = Pullampet formations.

Fluvial landforms: Most of the rivers in the southern part of the basin have old flood plain and young flood plain that can be easily identified from the satellite images. Most of the old flood plains are either under cultivation with intermittent sand patches exposed by the concentration of Palmera plantation. At the foot hills all along the western margin in the basin and eastern margin well developed Piedmont zones are observed. In addition, there are number of valley fills in the basin. Alluvial fans are noticed at the foot of the Gandikota hill range. Karst topography: There are good numbers of areas covered by limestone having karst topography, especially in the Kurnool Group. These areas exhibit typical karst features and the Kurnool caves developed in the limestone are very popular as tourist spot. All the karst features like caves, caverns, stalactites and stalagmites are observed in the caves. Denudational landforms are mostly seen in the dolostone terrain of the Vempalle Formation in the western part of the Papaghni sub-basin.

EROSIONAL SURFACES

The planation surfaces are regional and the study of such surfaces should be based on the regional data. Hence the Cuddapah basin and its surrounding areas are studied for a clear understanding of surfaces and their inter-relationship. The critical study of cross sections along certain latitudes and along the hill ranges revealed a number of erosional surfaces in and around Cuddapah basin. International sheets (1:1000, 000) are used to mark the various surfaces. These surfaces are correlated with the surfaces noticed in the Karnataka and Tamilnadu also (Figure 5).

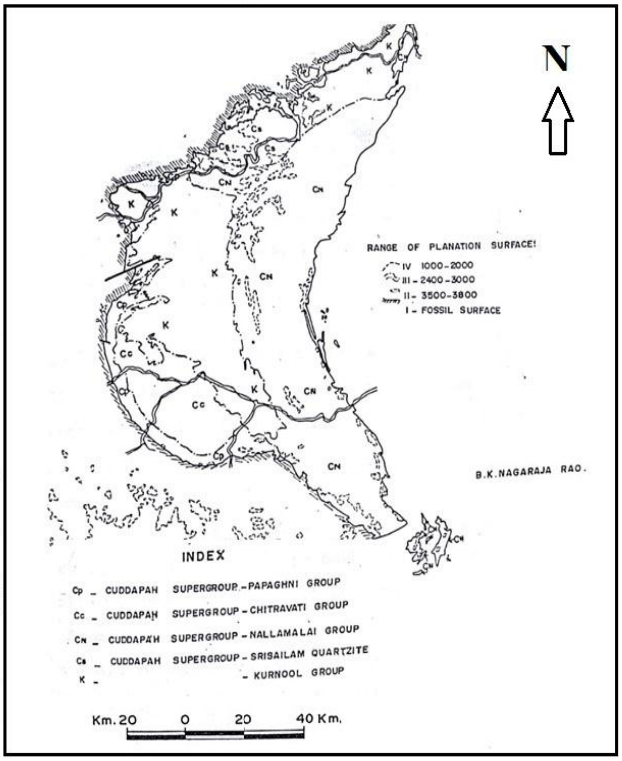

Fig 5: Range of Planation in the Cuddapah basin corresponding surface in the craton.

1. This surface is not recognized in the Cuddapah basin and around it. This is noticed across Annamalai, Palani and Nilgiri and Shevaroy hills. Remnants of surface are observed at an altitude of over 8000' (2424 m). This is named as Annamalai surface.

2. This surface is recognized at 6500'-7500' (1969-2272 m) on the western side of the Peninsula. On the eastern side it comes down to about 3500' (1060m) as noticed in Tirumala hills. Southwest of Cuddapah basin in the Chikaballapur, Nandidurg and in Kolar areas, this surface is better preserved in the adjacent areas compared to the Tirumala hills. On the Tirumala hills it is noticed at a height of 3776' in the quartzite horizon in the southern tip of the basin and at 3625' in the Velikonda hill ranges where the lithology in the quartzite and phyllite sequence. These are the erosional remnants of 2 surfaces which are better preserved in the south western part outside the limits at the Cuddapah basin. As this surface is well developed around Ootacamund, this is designated as Ootacamund surface.

3. This surface was given different surface ranges by different people as cited.2700'-3000' (Vaidyanathan, 1964). 2700-3300 (Subramaniam, 1979) 2400-3000 (Radhakrishna, 1952). The range shown by Subramaniam is taken as a standard and the distribution of this surface in and around the basin is shown in the map (Fig.5). This is again well preserved in the south western part beyond the limits where it has comparatively more aerial extent than in the Cuddapah basin. This is best preserved and identified around Chikaballapur, Nandidurg and Bangalore.

In the Cuddapah basin, this surface is not noticed on the Palakonda hill range i.e.in Tirumala hills which constitute mainly quartzite and siliceous shales, where the hills are of the order of 3366' and 3350'. In the Nallamalai and Velikonda hill ranges, where the lithology is phyllite and quartzite, the hills are not in the order of 2930' and 3445' and 2698' area this has been identified as Karnataka surface.

4. This is developed extensively around the Cuddapah basin. In the Cuddapah basin also the development of this surface is of considerable magnitude. There is a general agreement on the range of this surface i.e. about 1600-2000'. This is well preserved in the Palakonda, Velikonda and Nallamalai ranges and Irlakonda plateau in the basin, but occurs as erosional remnants in the Seshachalam hill range. It is also well preserved in the north western part beyond the limits of Cuddapah basin also. Further to east of Cuddapah basin, this surface is not preserved. This surface is named as Hyderabad surface as it is well developed around Hyderabad.

5. This is extensively developed to the east of Cuddapah basin limits and much inland within the basin. The rivers in the Cuddapah basin are responsible to the great extent for the development of this surface inland. This surface is called as' Coastal surface'. Residual deposits mainly Mn, Laterite and Fe are recorded on this surface in the Cuddapah basin.

Fossil surface

Sharp (1940) recognized the Eparchaean and Ep-Algonkian unconformities as the fossil surfaces in Grand Canyon of the Arizona. The Eparchaean unconformity beneath the Cuddapah basin is also similar to that as explained by Sharp. This is identified throughout the western margin of the Cuddapah basin. The characters of the fossil surface as described by Sharp,1940 are (a) extreme smoothness is its principal feature (b) it represents ultimate form of erosional cycle and finally (c) Eparchaean surface is usually referred to as pen plain.

The weathering of the granitic basement, the alteration of biotite into chlorite, the chemical weathering are the characters of this surface in the

Cuddapah basin area. The unconformity surface between the basement and the Cuddapah sediments has slight undulatory nature and has gentle inclination towards east which is very clear as one approaches the famous hills of the Tirumala from Renigunta side. The gentle inclination and smoothness of the surface are conspicuous further up hills in Tirumala.

The extensive hydrogeological and electrical resistivity studies and collection of well – log data around the talus covered slopes of Nagari Quartzite around Tirupati, Tirumala, Srikalahasti and Karakambadi has revealed that thick deposits of weathered and fractured shales occur in between granites and quartzites (i.e. on the unconformity plane) at certain places (Jagadiswara Rao and Sudheer, 1977). The weathered and fractured shale beds along the unconformity described by Jagadiswara Rao and Sudheer, explains the alteration of feldspar on the fossil surface. Similar features are suggested by Sharp in the Grand Canyon area also. Hence, the unconformity between the granitic basement and the Cuddapah sediments represents the fossil surface.

Cuddapah basin appears to have the 'Indian surface' (King 1950) which according to him is Cretaceous to mid- Tertiary. However, the Cuddapah basin has basically four surfaces i.e. II, III, IV and V and fossil surface also. The surfaces described by Vaidyanathan (1964) i.e., 3000 '-2700' and 2000 '-1600' (correlated to the 3000'-2800' and 2000' plateau surfaces of Radhakrishna, 1952 are correlated to III and IV surfaces. Considering one of the fundamental concepts of geomorphology (Thornbury, 1986) i.e., little of the earth's topography is older than Tertiary and most of it is no older than Pleistocene; the third surface could be post- Miocene and the lower Pliocene in age (Vaidynathan, 1964).

PROCESSES

There are a few geomorphic processes in the basin. The important processes are rock fall, landslides and sheet wash.

Rock fall

This is noticed mainly in the western margin and to a certain extent in the eastern margin, wherever the scarp faces are exposed. At present this is due to the head ward erosion of streams facilitated by the cross joints. Major blocks of various dimensions which have rolled down from the scarp can be seen on the obsequent slopes facing the Sri Venkateswara University buildings. These slopes are stabilized and the blocks through precariously positioned do not roll down further. This process has resulted in the scarp retreat at many places. The frost action might be responsible for the rock fall process in the past.

Landslides

These are observed in the new ghat road to Tirumala. The actual landslides are occurring in the basement rocks, but are involving the overlying Nagari Quartzite also. The occurrence of the landslide is mainly due to human influence. One such landslide has removed the overlying Nagari Quartzite block which is bigger than the size of a Willy's jeep. There are minor landslides along this road in the higher reaches. As said earlier the occurrence of the landslides is purely due to the human influence.

CONCLUSIONS

The study of geomorphology of the Cuddapah basin has clearly indicated umpteen geomorphic features especially the planation surfaces and fossil surface. The concept of geomorphology i.e. lithology controls evolution of landforms is reflected very clearly throughout the basin. The Papaghni sub-basin that is structurally least disturbed has typical set of landforms like cuesta, homocline and fluvial landforms like piedmont zone, alluvial fans etc. The Nallamalai sub-basin called Nallamalai fold belt has spectacular domal features, doubly plunging anticlines and all other structural features.

The first and second order topography is also observed north and south of Cheyyeru River respectively in the Nallamalai sub-basin. Different planation surfaces have been recognized in the Cuddapah basin. Fossil surface as described by Sharp (1940) has also been identified. The spectacular natural arch at Tirumala is one of the important geomorphic features and is also the tourist attraction in the basin. It is submitted that further detailed work on the geomorphology is still under progress.

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